AMENDMENT TO THE CLAIMS

This listing of claims will replace all prior versions, and listings, of claims in the application. The following listing provides the amended claims with deleted material crossed out and new material underlined to show the changes made.

1. (Previously Presented) Multiple-effect distillation method, intended for separating substances in solution from their liquid solvent, in particular for producing fresh water or concentrates, in which:

- counter-current heat exchanges are carried out by a single liquid or gaseous heat-transfer fluid, circulating in closed circuit along surfaces, hot Sc and cold Sf respectively, linked by significant thermal conductance;

- said surfaces Sc and Sf are faces of walls of thin distillation-heat-exchange hollow plates, installed in large numbers, vertical or inclined, in a heat-insulated treatment chamber, comprising narrow inter-plate spaces, of more or less constant width, filled with a non condensable gas, in particular air at atmospheric pressure; wherein:

- the heat-transfer fluid circulates, in a first upward or downward direction, along the surfaces Sc, passing from a high initial temperature T1 to a final temperature T3 below T1, then in a second direction opposite the first, along the surfaces Sf, passing from an initial temperature T4, below T3, to a final temperature T2, above T4 and below T1;

- at the top of the external faces of the walls of the hollow plates, inside which the heat transfer fluid circulates in said first direction, liquid to be distilled is poured which spreads out and runs down slowly in fine layers along these external faces;

- under the action of the flow of heat-transfer fluid circulating in said first direction, some of the liquid to be distilled poured over said external faces evaporates, whilst this

flow cools down, passing from T1 to T3, and the vapour produced diffuses in the non-condensable gas present in the inter-plate spaces;

- under the action of the flow of heat-transfer fluid circulating in said second direction, the vapour diffused in the non-condensable gas condenses, whilst this flow heats up again, passing from T4 to T2, under the effect of a recovery of a significant part of the latent heat of condensation of the diffused vapour;

- a heat source is arranged between the hottest ends of the surfaces Sc and Sf, in order to increase the temperature of the heat-transfer fluid from T2 to T1;

-a cold source is arranged between the least hot ends of these surfaces Sc and Sf, in order to reduce the temperature of the heat-transfer fluid from T3 to T4;

- a more or less constant local difference dH in enthalpy flows is established between the surfaces Sc and Sf, by giving appropriate amplitudes to the heat exchanges carried out between the flow of heat-transfer fluid and said hot and cold sources respectively;

- the optimum temperatures of the heat-transfer fluid T1, T2 and T3, T4, at the ends of these same surfaces, are determined from the maximum Intrinsic Efficiency Criterion CIE = Q2/P.V of the installation, Q being the exchanged distillation thermal power, P being the thermal power provided by the heat source, and V the active volume of the installation.

2.   (Previously Presented)   Distillation method with vapour diffusion, according to claim 1, in which:

- the heat-transfer fluid is the liquid to be distilled;

- the thin, hollow distillation-heat-exchange plates are hot or cold and they are installed alternating in the heat-insulated treatment chamber, the internal faces of their respective walls constituting said hot Sc and cold surfaces Sf;

- liquid to be distilled is poured over the external faces of the walls of the hot plates only; wherein:

- the heat-transfer liquid circulates, in a first upward or downward direction, inside the hot plates, it enters very hot at temperature T1 and it exits cooled down to the temperature T3, having caused a partial evaporation of the liquid to be distilled flowing over the external faces of the walls of these hot plates;

- at the outlet from these hot plates, the heat-transfer liquid at temperature T3 is cooled down to temperature T4;

- then, the heat-transfer liquid at temperature T4 enters inside the cold plates where it circulates in a second direction, opposite the first, causing, on the external faces of the walls of these cold plates, a condensation of the vapour diffused through the layer of non-condensable gas in the inter-plate space and recovering some of the condensation heat from this vapour in order to be heated up again, and finally it exits from the cold plates at temperature T2;

- during these operations, the flow of heat passes through the walls of the hot and cold hollow plates as well as the immobile layers of non-condensable gas which separate them;

- the distilled liquid runs down along the external faces of the walls of the cold plates whilst the concentrated liquid runs down along the external faces of the walls of the hot plates;

- the optimum temperature T1 of the heat-transfer liquid, at the inlet to the hot hollow plates, is as little as possible below the boiling temperature of this liquid at atmospheric pressure;

- the optimum temperature T3 of the heat-transfer liquid, at the outlet from the hot hollow plates, is relatively high and situated in a range which corresponds to a zone surrounding the maximum Intrinsic Efficiency Criterion CIE of the installation;

- the differences in temperature (T1-T2) and (T3-T4) are small, with (T1-T2) being slightly greater than (T3-T4).

3.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer liquid, according to claim 2, wherein:

- the correspondence between the optimum range of the temperatures T3 and the maximum CIE, is achieved by means of their respective relationships with a composite variable t.dT, in which t is the transit time of the heat-transfer liquid in the plates and dT the difference in temperature between the liquids circulating in the cold and hot hollow plates;

- the optimum difference in temperature dT is established by an adjustment of the ratio between the heating power of the heat source and the mass flow rate D of circulating heat transfer liquid;

- the optimum value chosen for dT is relatively high when the unit cost of the thermal energy easily available at the site of implementation of the method is relatively low;

- the useful range of the temperature T3 is the range from 58 to 78°C, when the liquid to be distilled is water;

- the optimum transit time t of the heat-transfer fluid in the heat-exchange plates is established by adjustment of the mass flow rate D of the heat-transfer liquid circulating in a closed loop.

4.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer liquid, according to claim 3, in which the heat-transfer liquid circulates, by thermosiphon or by pumping, from the top downwards inside the hot hollow plates and from the bottom upwards inside the cold hollow plates, wherein:

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- a heat exchange for heating is carried out between the flow d of liquid to be distilled entering the installation at temperature TL1 and the two flows of distilled and concentrated liquids leaving it, so as to take the temperature of this flow d to a relatively high optimum intermediate value TL2;

- mixing is carried out between this entering flow d thus heated and the flow D of heat transfer liquid exiting from the hot plates at temperature T3, the ratio d/D being adjusted so that the mixture thus produced is at an optimum temperature T4 at the inlet to the cold plates.

5.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer liquid, according to claim 3, wherein:

- the heat-transfer liquid circulates by thermosiphon, from the bottom upwards inside the hot hollow plates and from the top downwards inside the cold hollow plates;

- the flow d of liquid to be distilled entering at temperature TL1 is added to the flow D of heat transfer liquid exiting at the temperature T3 of the hot plates, the ratio d/D being adjusted so that the mixture thus produced is at an optimum temperature T4 at the inlet to the cold plates;

- a flow d of liquid at temperature T3 or T4 is poured over the top of the external faces of the hot plates.

6.   (Previously Presented)   Distillation method with vapour diffusion, according to claim 1, in which:

- the heat-transfer fluid is said non-condensable gas, saturated with vapour of the liquid to be distilled;

- liquid to be distilled is poured over the top of the external faces of the walls of all the distillation-heat-exchange hollow plates, these external faces constituting said cold surfaces Sf whilst the internal faces of the walls of these plates constitute said hot surfaces Sc; wherein:

- the flow of heat-transfer gas at temperature $T1$ enters inside all the hollow distillation plates, where it circulates in a first upward or downward direction, whilst some of its vapour condenses on the internal faces of the walls of the plates, flows of heat, resulting from a virtually total recovery of the latent heat of condensation, pass through the walls of the plates in order to evaporate some of the liquid flowing over the external faces of these walls and, as a result, this flow of gas cools down and finally exits from the hollow plates at temperature $T3$;

- at the outlet from these plates, this flow of heat-transfer gas at temperature $T3$ is cooled down to temperature $T4$ by heat exchange and the distilled liquid, condensed on this occasion, is recovered;

- then, this flow of heat-transfer gas, at temperature $T4$, enters the inter-plate spaces, where it circulates in a second direction, the reverse of the first, carrying away the vapour produced in these spaces and reheating it, and finally it exits from these spaces at temperature $T2$;

- the distilled liquid, condensed on the internal faces of the walls of the hollow plates, runs down along these internal faces whilst the concentrated liquid runs down along the external faces of these walls;

- the optimum temperature $T1$ of the flow of heat-transfer gas, at the inlet to the hollow plates, is situated within a wide range surrounding the maximum Intrinsic Efficiency Criterion CIE of the installation;

- the temperature T4 of the flow of heat-transfer gas, at the inlet to the interpolate spaces, is optimum when, by appropriate cooling, it is made as close as possible to the minimum temperature of the natural cold source available at the site;

- the difference in temperature (T1-T2) is small and the difference (T3-T4), considerable.

7. (Previously Presented) Distillation method with vapour diffusion and heat-transfer gas, according to claim 6, wherein:

- the correspondence between the optimum range of the temperatures T1 and the maximum CIE zone is achieved by means of their respective relationships with a composite variable t.dH/V, in which t is the transit time of the heat-transfer gas in the hollow plates and dH a more or less constant local difference in enthalpy flows between the internal and external faces of the walls of the hollow plates;

- the useful range of the temperature T1 is approximately comprised between 74 and 91°C;

- the optimum local difference in enthalpy flows dH, between the internal and external faces of the walls of the hollow plates, is established by adjustment of the ratio between the heating power of the heat source and the circulating mass flow rate D of the heat-transfer gas;

- the optimum value of the difference dH is higher when the CIE and the cost of the thermal energy easily available on site are relatively low;

- the optimum transit time t of the flow of heat-transfer gas in the hollow plates is established by adjustment of the mass flow D of this flow of gas.

8.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer gas, according to claim 7, wherein, according to a first set of arrangements,

- the flow of gas at temperature T1 is introduced at the top of the hollow distillation plates and it exits at the bottom at temperature T3;

- at the outlet from the hollow distillation plates, this flow of gas at temperature T3 is subjected to a first cooling-down heat exchange, ensured by a cold source at temperature TL1, constituted by the entering flow of liquid to be distilled, in order that, given the respective mass and thermal characteristics of this flow of gas and of this flow of liquid, the temperature T3 of the flow of gas is reduced to an optimum temperature T4 and the temperature of the liquid taken to TL2;

- after this heat exchange, the liquid to be distilled at temperature TL2 is reheated by a heat source;

- the flow of gas at temperature T4 is introduced at the bottom of the inter-plate spaces and it exits at the top at temperature T2;

- the flow of gas circulates in closed circuit in the hollow plates and in the inter-plate spaces, under the action of at least one means of propulsion;

- at the outlet from the inter-plate spaces, the flow of gas at temperature T2 is reheated and saturated with vapour, by an appropriate physical contact with the liquid to be distilled reheated by the heat source, so as to take on an optimum or simply effective temperature T1;

- after its physical contact with the flow of gas at temperature T2, the liquid to be distilled is poured, at a temperature of approximately T1, over the top of the external faces of the walls of the hollow plates, and it exits at a temperature of approximately T4;

- the distilled liquid, condensed during said cooling-down heat exchange, and that condensed on the internal faces of the hollow plates, are collected, then removed and recovered;

- the concentrated liquid is collected at the bottom of the external faces of the walls of these plates, then it is removed and, if appropriate, recovered.

9.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer gas, according to claim 8, wherein:

- said hollow distillation plates forming a large number N of plates, a small flow of heat transfer gas at temperature T1 is introduced into a small number n of hollow auxiliary reheating plates, in order to participate in a second heat exchange, intended to reheat the liquid to be distilled exiting from a third heat exchange;

- the flow of liquid to be distilled which exits reheated from this second heat exchange is introduced into the heating chamber of the boiler, in place of that exiting previously from the first heat exchange;

- on exiting from these n hollow reheating plates, the small cooled-down flow of heat transfer gas is mixed with the flow of heat-transfer gas exiting from the N hollow distillation plates, then the mixture is subjected to said first heat exchange, in order to exit from it at said temperature T4;

- the liquid to be distilled exiting from the first heat exchange is reheated, during said third heat exchange, by the distilled liquid which has condensed on the internal faces of the walls of the (N+n) plates;

- the flow rates of distilled liquids, produced at the outlet from these (N+n) hollow plates and during the first heat exchange, are mixed then removed and recovered.

10.   (Previously Presented)   Distillation method according to claim 9, wherein:

- the heat source is a boiler provided with a heating chamber operating at a constant level of liquid and suited to producing very hot liquid and vapour jets;

- the very hot liquid to be distilled is spread over a support, in order to be swept by the flow of heat-transfer gas at temperature T2;

- the vapour jets constitute means of propulsion intended to cause the flow of heat transfer gas to circulate in closed circuit and in the opposite direction to natural convection, and, moreover, to reheat and supersaturate this flow in order to take it to an optimum or simply effective temperature T1;

- the heating power of the boiler is variable and the flow rates of hot liquid and of vapour are controlled by adjusting this power.

11.   (Previously Presented)   Distillation method with vapour diffusion and heat-transfer gas, according to claim 7, wherein, according to a second set of arrangements,

- the flow of saturated gas at temperature T1 is introduced at the bottom of the hollow distillation plates and it exits at the top at temperature T3;

- at the outlet from the hollow distillation plates, this flow of gas is subjected to a cooling-down heat exchange, ensured by a cold source at temperature TL1, constituted by the entering flow of liquid to be distilled, so that, given the mass and thermal characteristics of this flow of gas and of this flow of liquid, the temperature T3 of the flow of gas is reduced to an optimum temperature T4 and the temperature of the liquid taken to TL2;

- after this heat exchange, the liquid to be distilled at temperature TL1 or TL2 is poured over the top of the external faces of the walls of the hollow plates, it runs down along these external faces and leaves them at a temperature of approximately T2;

- the flow of gas, at temperature T4, is introduced at the top of the inter-plate spaces and it exits at the bottom at temperature T2;

- at the outlet from the inter-plate spaces, the flow of gas at temperature T2 is subjected to the action of a heat source, in order to be reheated and saturated with vapour, and taken to an optimum or simply effective temperature T1;

- the flow of gas at temperature T1 is introduced at the bottom of the hollow plates and, at least by natural convection, it rises inside these plates, then it exits at the top, it then passes through a zone where it undergoes said cooling-down heat exchange then, at temperature T4, it enters and runs down by gravity in the inter-plate spaces;

- the distilled liquid, condensed during the cooling-down heat exchange and that condensed along the internal faces of the walls of the hollow plates are collected, then removed;

- the concentrated liquid is collected at the bottom of the inter-plate spaces with a view to immediate or subsequent removal.

12.   (Previously Presented)   Distillation method according to claim 11, wherein,

- on exiting from the inter-plate spaces, the concentrated liquid is reheated by a heat source;

- the flow of gas exiting from these inter-plate spaces is reheated and saturated by appropriate physical contact with the concentrated liquid, reheated by this heat source;

- the slightly more concentrated liquid which results from the preceding operation is, if appropriate, collected in a reservoir, from where it is removed periodically.

13.   (Previously Presented)   Distillation method according to claim 11, wherein:

- before being removed in continuous manner, the distilled liquid collected circulates from the bottom to the top in a small group of hollow auxiliary heat recovery plates, separated by narrow inter-plate spaces;

- if appropriate, the same applies to the condensed liquid collected;

- these hollow auxiliary heat recovery plates are at the same time rigid, thin and provided with external, hydrophilic or wettable coatings;

- liquid to be distilled, preferably as cold as possible, is poured over the top of these coatings;

- a part of the flow of gas at temperature T4 circulates from the top downwards along these thus moistened coatings;

- the flow of saturated hot gas which leaves these coatings is added to that which exits from the inter-plate spaces of the hollow distillation plates, then the mixture is reheated and saturated in order to reach an effective or optimum temperature T1;

- the distilled and concentrated liquids exit cooled down again at the top of these hollow auxiliary heat recovery plates then they are removed and at least one of them is recovered.

14.   (Previously Presented)   Distillation method according to claim 12, wherein:

- the heat source concerned is a solar boiler, suited to heating a thin hydrophilic mat, inclined as a function of the latitude of the installation site;

- the concentrated hot liquid which flows from the inter-plate spaces, ends up in a trough into which the top part of this hydrophilic mat is dipped;

- the concentrated hot liquid which flows from this hydrophilic mat is collected in a heat insulated reservoir, the surface of which is both uncovered and also as wide as possible

and the depth sufficient for it to be able to contain the concentrated liquid produced during one day;

- the flow of gas, which exits from the inter-plate spaces, is directed towards the surface of the hot liquid contained in this reservoir, in order to sweep across it and thus benefit from preheating;

- then, the flow of gas thus preheated sweeps over this hydrophilic mat, heated during the day and constantly moistened by the concentrated liquid, in order to be reheated and saturated, before entering the bottom of the hollow distillation plates;

- the reservoir is emptied every morning, so that a limited additional distillation can be carried out during the night.

15.   (Previously Presented)   Distillation method according to claim 12, wherein the heat source concerned is a heating tube provided with a hydrophilic coating with clear slopes, over which is poured the concentrated liquid which flows from the inter-plate spaces, the very concentrated liquid produced being removed continuously.

16.   (Previously Presented)   Distillation method according to claim 11, wherein:

- the heat source concerned is constituted by vapour jets, installed at a good distance and orientation, upstream of the inlets to the hollow plates;

- these vapour jets reheat and saturate the flow of gas exiting from the interpolate spaces and, moreover, they constitute auxiliary means of propulsion which increase the speed of circulation by natural convection of this flow and can thus give an optimum value to the transit time of this flow of gas in the hollow plates;

- the concentrated liquid exiting from the inter-plate spaces is collected and removed continuously.

17. (Previously Presented) Distillation method according to claim 16, wherein a ventilator is used just upstream of the inter-plate spaces, in order to increase the circulating flow.

Claims 18-20. (Canceled)

21. (Previously Presented) Still with vapour diffusion and heat-transfer gas, in particular for producing fresh water or concentrates, according to the distillation method of claim 8 comprising:

- a distillation unit, constituted by a large number N of thin hollow plates, large and separate or small and integral, and by narrow inter-plate spaces, filled with a non-condensable gas, in particular air at atmospheric pressure, constituting said heat transfer gas;

- means of propulsion for causing the saturated heat-transfer gas to circulate, in closed circuit, from the top downwards inside the hollow plates and from the bottom upwards in their inter plate spaces;

- means for pouring the hot liquid to be distilled over the top of the plates;

- means for collecting the distilled liquid, condensed on the internal faces of the plates, and means for collecting the condensed liquid which flows along their external faces;

- a heat source, arranged between the top ends of the plates and of the inter-plate spaces, and a cold source, arranged between their bottom ends;

wherein:

- the heat source is installed just above the plates, in the middle of the flow of heat transfer gas exiting from the inter-plate spaces in order to enter inside the hollow plates, in order to take the temperatures of this flow to T2 and T1 and, on this occasion, to supersaturate it in vapour;

- this heat source comprises a tray, if appropriate covered with a spongy mat, provided with a base perforated with small holes, associated with ducts and/or distribution wicks, this tray being installed under one or more tubes for extraction of the hot liquid to be distilled present in the heating chamber of a boiler;

- the cold source is constituted by a first heat exchanger comprising an active element, enclosed in a casing;

- the inlet of this active element is connected to a reservoir of cold liquid to be distilled, if appropriate, through an auxiliary device with natural cooling, and its outlet, connected by appropriate means to the inlet to the heating chamber of the boiler;

- the inlet of the casing is connected to the outlet from the N separate or integral hollow plates, and its outlet to the inlet to the inter-plate spaces;

- the means of propulsion are constituted by a ventilator, installed upstream of the inlets to the inter-plate spaces, and/or by vapour jet, engendered upstream of the inlets to the hollow plates;

- the casing comprises a duct for removal of the distilled water produced, which cooperates with the means intended for collecting that which flows from the bottom of the N hollow plates.

22.   (Previously Presented)   Still with vapour diffusion and heat-transfer gas, according to claim 21, wherein:

- a small number n of hollow auxiliary plates is installed in the vicinity of the N hollow plates of the distillation unit, in order to constitute a second heat exchanger with counter-current operation, between a small part of heat-transfer gas, saturated at temperature T1 and the flow of liquid to be distilled which exits from a third heat exchanger, arranged between the outlet from the first heat exchanger and the means for collecting distilled liquids which flow over the internal faces of the walls of the (N+n) hollow plates;

- the N hollow plates of the distillation unit and the n auxiliary plates open into a duct with a common outlet, connected to the casing of the first heat exchanger;

- the distilled liquid which exits from the n auxiliary plates is added to those which exit from the N distillation plates and from the casing of the heat exchanger.

Claims 23-37. (Canceled)